

NATIONAL BUREAU OF STANDARDS

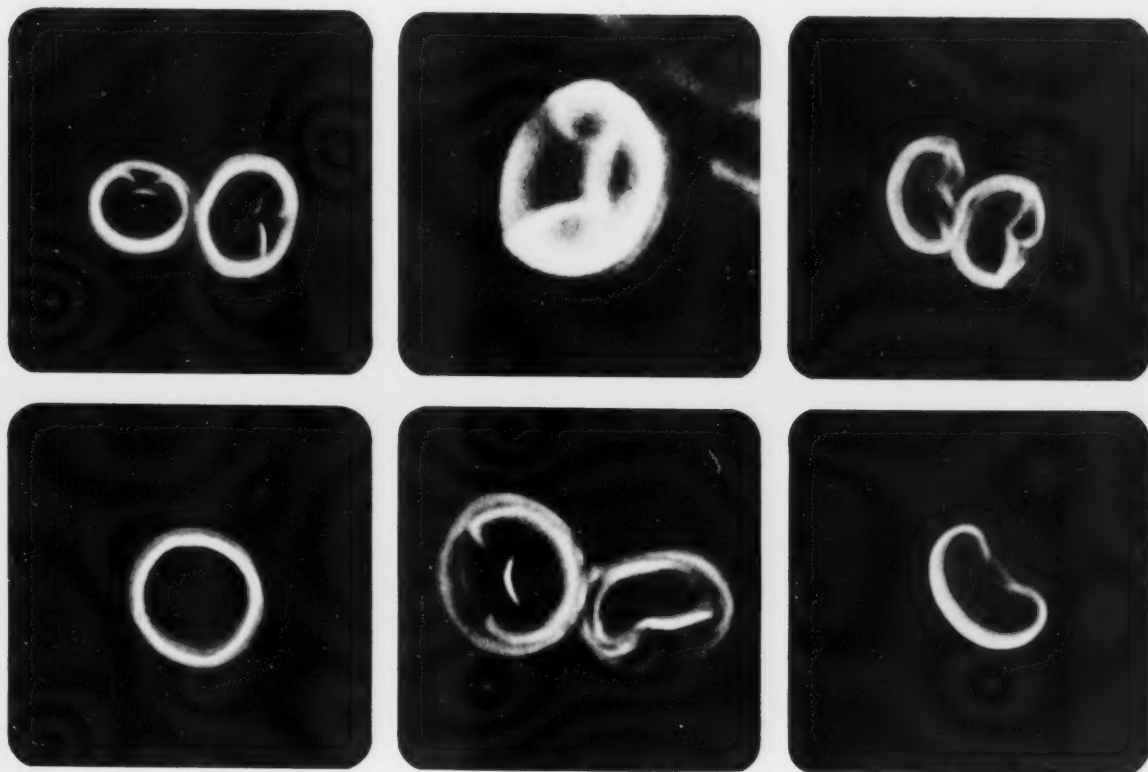
October/1968

Technical News Bulletin

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TECHNOLOGY & SCIENCE



U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

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U.S. DEPARTMENT OF COMMERCE

C. R. Smith, Secretary

NATIONAL BUREAU OF STANDARDS

A. V. Astin, Director

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COVER: These unusually shaped polymer crystals are examples of a novel phenomenon observed by scientists in the NBS Polymers Division in recent studies on three polymers. Their investigations revealed that the lower the temperature at which these polymers crystallize from solution, the more pronounced is the curvature of the crystals formed in suspension in the solvent. These four-fold symmetrical hollow bowl-shaped objects, shown in different perspectives, are curved crystals of tetragonal poly(4-methylpentene-1). The habit of these crystals contrasts vividly with that of the square-shaped platelets formed at higher crystallization temperatures. (Phase contrast optics, about $\times 1300$.)

Prepared by the NBS Office of Technical Information and Publications, Washington, D.C. 20234

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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:

- The Institute for Basic Standards
- The Institute for Materials Research
- The Institute for Applied Technology
- Center for Radiation Research

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Robert A. Lawton assembles the 3-port component of his newly developed precision rf current comparator.

PRECISION COAXIAL CURRENT COMPARATOR

Circuits Unaffected by Insertion of Network

Measurements of voltage in a circuit are readily made with high accuracy by potentiometers for direct current and with transfer techniques over a broad frequency range. Current, on the other hand, is usually measured by measuring the voltage across a known impedance in the circuit. While this method is useful for dc and over much of the ac range, the impedance introduced often results in an error-producing change in current.

C. M. Allred and R. A. Lawton, of the NBS Radio Standards Engineering Division in Boulder, Colo., have recently designed and tested a device that virtually eliminates the error due to added impedance.¹

The new apparatus, called a precision current comparator, makes current measurements by supplying an equal and opposite voltage to the voltage existing across an impedance so that the net voltage is zero and effectively the impedance becomes zero.

In an application using coaxial lines, the device enables current measurements to be made literally "from the inside" of the circuit instead of using exterior attachments. A 0.001-inch gap in the line samples the current, but because of the peculiar voltage compensation, measurements in the external circuit indicate that the line was effectively solid and continuous. Therefore the current is not perturbed by the comparator.

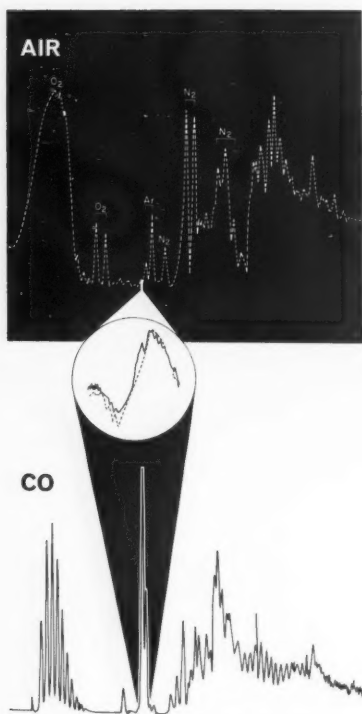
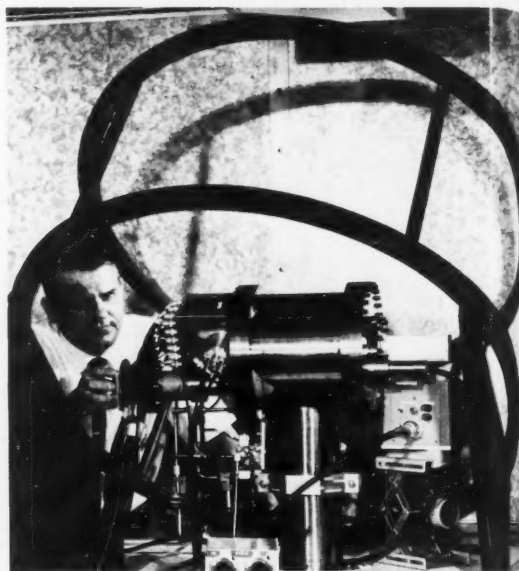
The amplitude of the opposing voltage is set by precise adjustable attenuators and its phase by precision phase shifters. The voltage ratios are measured at the terminal to which the voltage source is connected. The ratio of the null-producing voltages for any two currents is the ratio of the currents themselves; if one current is known, so is the other. The known current could be a standard current source at an optimum level for greatest accuracy.

The new current comparator was originally developed for use in measuring the relative amplitude and phase distribution of the current on a thick circular cylindrical antenna. The principle of the device applies to measurements over the entire radio-frequency range, although the hardware and technique may be specific to certain frequencies.

¹ Allred, C. M., and Lawton, R. A., A precision current comparator, IEEE Trans. Instr. Meas. IM-16, 142-145 (June 1967).

IMPACT SPECTROMETER FOUND VALUABLE IN TRACE ANALYSIS

Stanley Mielczarek makes an adjustment on the spectrometer within its evacuated housing. Double circular loops counteract the earth's magnetic field.



A three-part graph illustrates the sensitivity of the electron impact spectrometer. The upper portion charts relative proportions of the air's most prominent constituents; the lower portion is a spectrum of pure CO. The central graph shows an expansion of the spectrum of air as given by the impact spectrometer (1) with no CO (dashed curve), and (2) with 250 ppm of CO (solid curve).

An instrument called an electron impact spectrometer, developed four years ago at the National Bureau of Standards for research in atomic physics, has recently shown great potential in the field of chemical trace analysis. At its current state of development, the spectrometer can, for example, detect 15 parts per million of carbon monoxide in the presence of all the interfering constituents of normal air. The instrument's high resolution and sensitivity should make it valuable for use in trace analysis and in the detection and control of air pollution. Its full capabilities are being investigated in a joint program of NBS and NASA's Langley Research Center.

Developed by J. A. Simpson, C. E. Kuyatt, and S. R. Mielczarek¹ of the NBS Institute for Basic Standards, the electron impact spectrometer was originally designed for determining the electron-scattering characteristics of atoms and simple molecules. Its operation depends on the collision of electrons with gas atoms or molecules. Upon impact, the collision electrons transfer their energy to the electrons

bound within the atom, which are thus raised from the stable state to an excited energy level. The spectrometer disperses the collision electrons according to their energies after impact, and the resultant energy spectrum corresponds to the optical absorption spectrum of the gas.²

The apparatus includes an electron gun, monochromator,³ analyzer, and collector. This assembly is bent into an "S" for compactness and light weight and is enclosed in an evacuated housing, about a foot long. The gun generates the electrons in a well defined beam, which passes through the monochromator making a 180° turn. The electrons then collide with the various atoms and molecular compounds of the target gas. The electrons after the collision are dispersed in the analyzer as they traverse another 180° turn and are then collected.

In a recent analysis of such spectra at NBS many more well defined peaks appeared than were expected for the specific gas sample under study. Apparently other gases, present only in trace quantities, were showing up in the spectrum. To test this hypothesis

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NBS INITIATES LIQUID HELIUM STUDY

The NBS Institute for Basic Standards recently initiated a long-range study to facilitate the use of liquid helium as a coolant for low-electrical-resistivity and superconducting devices. The study is sponsored by the Atomic Energy Commission and is being carried out under the direction of V. D. Arp of the Cryogenics Laboratory in Boulder, Colo.

Superconductivity is the absence of electrical resistance in certain materials below a characteristic transition temperature; it is at present one of the most active fields of research in physics. While superconducting technology is currently applied mainly in areas of high-energy physics, controlled fusion, and aerospace research, the possibilities for large commercial applications exist in such areas as measurement devices, computer switching, levitation of high-speed trains, and superconducting transmission lines.

Although present and anticipated applications of superconductors require liquid or supercritical* helium cooling, there is a lack of basic data on many of the physical properties of helium in the supercritical region. The purpose of the NBS program is to produce information on heat transfer and associated fluid properties that is needed for the optimum design of systems using liquid helium as a coolant.

The physical properties of liquid helium change at a temperature of approximately 2.189 K (lambda point). The stable liquid between this point and the critical temperature is known as helium I. That form existing from the lambda point to absolute zero is called helium II.

The overall NBS program will include research on supercritical helium, and both helium I and II. The first phase of the investigation will mainly attempt to obtain data on the physical properties of helium I and supercritical helium; it will be coupled with an experimental program to determine heat transfer data.

Initially, research on helium II is expected to be concentrated on a critical review, oriented toward design information. Currently, the reported data are quite dispersed and difficult to translate into design use for large systems.

Results from the NBS program should prove extremely valuable to cryogenic engineers for the design and development of superconducting devices and systems related not only to present research and space projects, but also to proposed industrial and commercial uses.

*Supercritical helium is fluid helium existing at a pressure and temperature above the critical pressure and temperature of helium I.

and to determine the limits of the instrument's resolution and sensitivity, gas samples of known dilution were prepared for study. In analyzing these samples, the device demonstrated a sensitivity and a precision which are currently available only with the most refined analytical techniques. For example, in a study of the atmosphere, the naturally occurring argon and helium in the sample (approximately 0.2 nanogram and 0.2 picogram, respectively) were detected. In less favorable conditions where interference is a problem, as in detecting carbon monoxide in air, contaminants on the order of 10 parts per million have been detected. It is believed that this level can be lowered in all but the worst cases of interference.

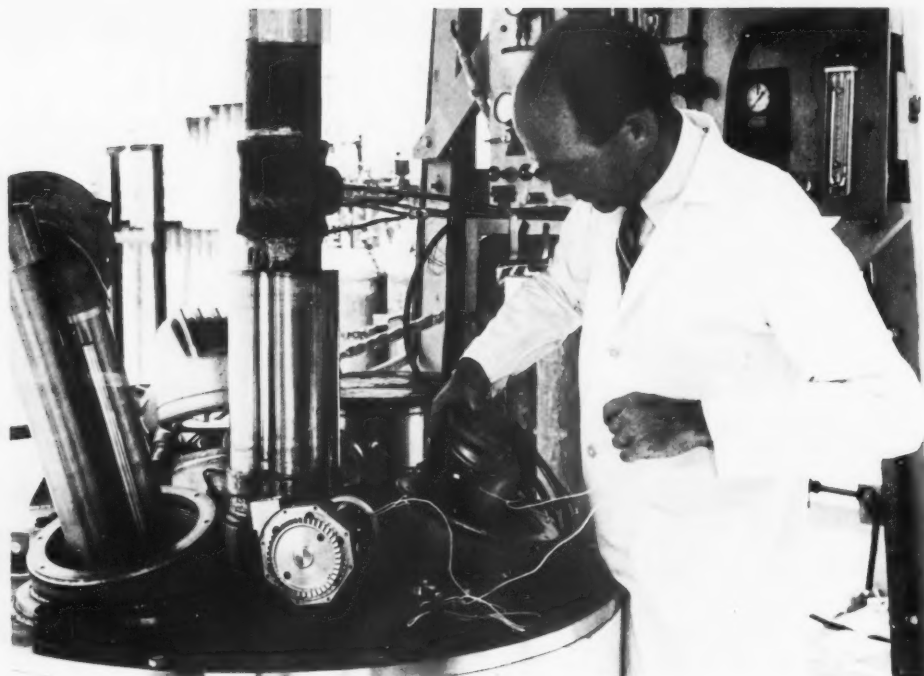
The electron impact spectrometer possesses a number of advantages over other analytical instruments. As compared to the mass spectrometer, the instrument it most resembles, the electron impact spectrometer is smaller, lighter in weight, and, at least for atoms and simple molecules, much less prone to interference between constituents of mixtures. For example, since CO and N₂ have an atomic weight difference that begins to occur in the third decimal place, difficulties present in the analytical mass spectrometer are absent in the impact spectrometer. Moreover, the problem of identifying the parent compounds from their fragments does not arise.

Compared to an optical absorption spectrometer, the electron impact spectrometer has a wider wavelength range (one run can cover energy losses corresponding to wavelengths from the x ray to the visible region). Since the response is linear, rather than exponential, with concentration, sensitivity is greatly improved and thus the spectra are easier to interpret.

¹ NBS develops new tool for exploring atomic structure, NBS Tech. News Bull. 48, No. 4, 64-68 (Apr. 1964).

² Simpson, J. A., Kuyatt, C. E., and Mielczarek, S. R., Absorption spectrum of SF₆ in the far ultraviolet by electron impact, J. Chem. Phys. 44, No. 12, 4403-4404 (June 1966).

³ Kuyatt, C. E., and Simpson, J. A., Electron monochromator design, Rev. Sci. Instr. 38, No. 1, 103-111 (Jan. 1967).



D. E. Daney installs a centrifugal-type, liquid hydrogen chill-down pump in the slush hydrogen generation equipment.

PUMPING CHARACTERISTICS OF SLUSH HYDROGEN STUDIED

The NBS Institute for Basic Standards recently completed a study¹ on the pumping characteristics of slush hydrogen—a mixture of solid and liquid hydrogen that shows high potential as a spacecraft fuel. This investigation, sponsored by the National Aeronautics and Space Administration, is part of an extensive characterization study on slush hydrogen to determine its practicality as a replacement for liquid hydrogen in certain advanced space missions. Slush hydrogen has several advantages over liquid hydrogen, which is now widely used as a rocket fuel. The greater density and smaller evaporation losses of slush hydrogen, for example, make it easier to store and transfer.

Previous slush-hydrogen research at the Bureau dealt with the development of a freeze-thaw technique for making a reproducible, flowable mixture of fine, solid hydrogen particles in a liquid melt. The size distribution and terminal velocity of the solid hydrogen particles were determined, and aging effects on the particles were investigated. In addition, an experimental flow loop was designed and constructed to study the flow relations and transport characteristics of slush hydrogen.

The pumping characteristics of liquid-solid mixtures of hydrogen, investigated during the latest phase of the Bureau's characterization program, are of considerable interest, since the use of slush as a rocket propellant will require that it be pumped on both ground installations and space vehicles.

The main objectives of the pump tests were to determine if slush hydrogen could be pumped with a conventional-type liquid hydrogen pump; to compare the pumping characteristics of liquid and slush hydrogen; and to investigate possible pump wear or damage due to the presence of solid particles.

The pump used in the tests is a commercially available, centrifugal-type chill-down pump, designed for the Saturn S-IV B, and modified by the addition of a helium gas-driven turbine and by the separation of the discharge volute from the motor housing. The latter modification was made so that the pump could be inserted and mounted inside a 120-gallon slush generator that is part of the slush hydrogen facility at NBS. When driven by the helium turbine, the pump has a variable speed of 6000 to 19 000 rpm, produces flow rates up to 350 gpm, and develops pres-

continued on page 224

NBS IMPROVES NULL-POINT POTENTIOMETRY

HIGH SENSITIVITY ATTAINED



Richard A. Durst makes instrument adjustments during operation of the Bureau-modified concentration cell assembly at right.

Recent NBS modifications to null-point potentiometry have made it one of the most sensitive tools now available for chemical analysis. Its increased accuracy and precision have enabled Bureau scientists to determine trace amounts of silver and fluoride in volumes as small as 10 microliters.¹ And, for the first time, fluoride has been determined at the subnanogram ($<10^{-9}$ g) level.

As modified by R. A. Durst and J. K. Taylor of the NBS Institute for Materials Research, the technique is equally promising for other fields of research. It is especially valuable in the areas of plant physiology (tracing the effects of fluoride) and oceanography (analyzing interstitial water squeezed out of corings) because the sample is not destroyed and can be analyzed in minute quantities.

In principle, null-point potentiometry is a simple titration technique

that compares the solution to be analyzed with a solution of known composition. The apparatus used for the titration is a concentration cell consisting of an analate half cell, a titration half cell, and a salt bridge. In the comparison, a known quantity of standard solution (titrant) is added to the titration half cell until its concentration is the same as that of the sample solution in the analate half cell.

In the NBS method, the analate and titration solution volumes are purposely made unequal, so as to provide an "amplification factor" for increasing the precision and accuracy of the determination. This "amplification factor"—the ratio of the volumes of the two solutions—works in the following way: If the volume of the titration solution is 100 milliliters and the volume of the unknown solution is 10 microliters, the ratio is 10-

000 to 1. Therefore, to make the concentrations of both solutions equal, the amount of the sought-for substance (fluoride, for example) added to the titration solution must be 10 000 times greater than the amount of analate in the unknown solution. The accuracy and precision are significantly increased by the addition of relatively concentrated titrant solutions by conventional rather than by microchemical techniques.

In the Bureau method for fluoride, the physical arrangement of the analate half cell electrode differs decidedly from the conventional arrangement. That is, the electrode is inverted and becomes the analate microcell.² Several advantages then follow from this arrangement: The sample does not become contaminated by the titrant solution, it is preserved for further studies, and it serves only as a reference solution. However, when the electrode was inverted, certain changes had to be incorporated in that portion of the microcell that contains the sample and the internal reference solution. One of these modifications was to convert the internal (liquid) reference solution to a gel, thus preventing air entrapment. Another change was to reduce the size of the sample container and thereby decrease the required sample volume to 10 μ l.

The potential of the concentration cell is measured by connecting the electrode leads to a pH meter (which serves as a voltage follower-amplifier for a potentiometric recorder) and allowing the system to come to equilibrium. The potential then is read from the recorder to the nearest tenth of a millivolt. When the recorder indicates the null potential, the analate concentrations in the two solutions are equal and the end point has been reached. Depending on the concentration of the solutions, a normal titration with four emf readings is

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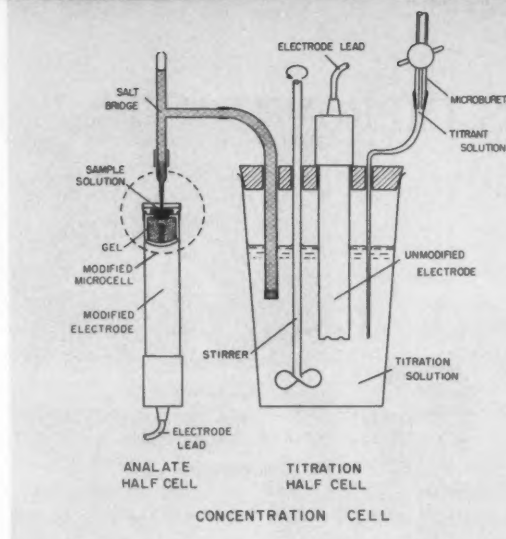
POTENTIOMETRY *continued*

completed in about 15 to 35 minutes, with less concentrated solutions requiring longer titration times because of slower equilibration.

The linear titration curve—a logarithmic plot of the amount of titrant added versus the cell potential (as determined from the Nernst equation)—was devised by Drs. Durst and Taylor to improve the precision and to serve as a check on possible errors occurring during titration. In the fluoride and silver determinations, computer analyses of the data complemented these graphical analyses.

The low levels determined in these measurements clearly rank the NBS technique as the most sensitive micro-analytical method for the determination of fluoride. In this method, 380 picograms (10^{-12} g) of fluoride were determined with an error of only 2 picograms at the concentration level

Unique features of this NBS cell are the inverted electrode (left) and the modified microcell (dotted circle).



of 2×10^{-6} M. For silver, the improved method has been found to be more precise in the lower concentrations than any other technique.³

¹ For further information, see Durst, R. A., and Taylor, J. K., Modified linear null-point potenti-

ometry, *Anal. Chem.* **39**, 1374 (1967). See also, Durst, R. A., Fluoride microanalysis by linear null-point potentiometry, *Anal. Chem.* **40**, 931 (1968).

² Durst, R. A., and Taylor, J. K., Modification of the fluoride activity electrode for microchemical analysis, *Anal. Chem.* **39**, 1483 (1967).

³ Durst, R. A., May, E. L., and Taylor, J. K., Improved technique for the microdetermination of silver by linear null-point potentiometry, *Anal. Chem.* **40**, 977 (1968).

SLUSH HYDROGEN *continued*

tures up to 26 psi. The specific speed range of the pump is from 1600 to 3100 rpm.

The NBS flow loop facility, used for the pump tests, consists essentially of the 120-gallon slush generating dewar, containing the pump; and a two-inch discharge line, which passes through an observation window to a 500-gallon receiving dewar. It was possible throughout the tests to pump the slush, produced in the generator by the freeze-thaw technique, to the receiver, or alternatively, through the return loop back to the generator. Globe valves, provided in the transfer line, allowed control of the flow and developed pressure of the pump.

Performance tests at 8000, 11 000, 14 000, and 19 000 rpm were made of both slush and triple-point liquid, with the generator and receiver pressurized to approximately one atmosphere with helium gas.

Cavitation tests, at 11 000 and 14 000 rpm, were also carried out. These tests were conducted in a manner similar to the performance tests, with the notable exception that the generator and receiver were initially pressurized to about 0.2 atmosphere.

During the performance and cavitation tests, the pump had a total running time of 79 minutes, of which time

slush hydrogen was pumped for a total of 33.8 minutes. Although in most cases the slush was freshly made, two runs were made with slush aged to six hours.

Throughout the tests measurement data were recorded of pressures, pump speed, liquid or slush volume, and slush density. The pressures were measured with transducers, mounted external to the generator; pump speed was sensed by a magnetic pickup, located at the splines in the pump shaft; liquid or slush volume was determined by ten carbon-resistor liquid-level sensors; and the solid fraction of the slush in the generator was measured by means of a nuclear radiation attenuation densitometer.

At the termination of the pump tests, an analysis of data and careful inspection of all pump parts resulted in the following conclusions: (1) As predicted from theory, pump performance and cavitation for slush and liquid hydrogen are the same when the difference in fluid density is considered; (2) both aged and fresh slush hydrogen, prepared by the freeze-thaw process, can be pumped by a properly-selected, conventional liquid hydrogen pump; and (3) slush hydrogen causes no additional wear to pump components over that caused by liquid hydrogen.

¹ Daney, D. E., Ludtke, P. R., Chelton, D. B., and Sindt, C. F., Slush Hydrogen Pumping Characteristics, NBS Tech. Note 364 (Apr. 1968).

CONFERENCE & PUBLICATION Briefs

WORKSHOP ON MASS SPECTROMETRY

Basic problems in mass spectrometry will be examined in a Workshop on Mass Spectrometric Analysis of Solids, which will be sponsored and hosted by the National Bureau of Standards, November 18 and 19, 1968, at its laboratories in Gaithersburg, Md.

The Workshop, open to all engaged in the mass spectrometry of solids, is designed to promote discussions of the basic problems in this area as well as to aid in the exchange of ideas, experiences, and techniques. A main topic on the agenda will be surface studies; an important part of that discussion will be the problems associated with the ion-probe mass-analyzing technique.

Program and registration information may be obtained from A. J. Ahearn or P. J. Paulsen, Rm. A121, Chemistry Bldg., National Bureau of Standards, Washington, D.C. 20234.

DIFFUSION OF ATOMS IN CRYSTALS

Drawing in part on his own contributions to the subject, John R. Manning, Chief of the Metal Physics Section of the NBS Institute for Materials Research, recently published *Diffusion Kinetics for Atoms in Crystals*,¹ a book whose aim, as described in its preface, is "to provide a systematic discussion of diffusion from an atomic random-walk approach." Books on diffusion generally include a brief description of the simple random-walk equations, but a sufficiently thorough and systematic treatment has been lacking. Dr. Manning's goal was to fill this gap in the literature.

Diffusion equations are derived by considering atoms that follow random walks or modified random walks. By tracing in detail the different possible paths of individual atoms and vacancies, the author relates large-scale diffusion measurements to atom jump frequencies and jump probabilities. Important modifications of the simple equations result from driving forces, diffusion coefficient gradients, and correlation effects, all of which are examined with some care.

Although emphasis is on the atomic approach, the less detailed, but for many purposes convenient, continuum approach is introduced in order to compare it with the results that follow from consideration of atomic mechanisms. To keep the work within bounds, only those diffusion mechanisms that are of importance at moderate and high temperatures are considered. This means that the discussion concentrates on diffusion in the interior of crystals in regions having a lattice structure, and no de-

tailed attention is given to diffusion depending on line or surface defects.

The first of the book's seven chapters sets forth the basic equations in a form consistent with kinetic theory. Chapter 2 deals with the uncorrelated random walk with constant diffusion coefficient; and correlation effects, which arise when the direction of one jump by a given atom influences the directions of succeeding jumps by that atom, are discussed in Chapter 3. In the next two chapters, major modifications of the random-walk equations are derived for such driving forces as electric fields, chemical concentration gradients, and temperature gradients. In Chapter 6, thermodynamic continuum equations are discussed and compared with the kinetic equations derived in the preceding chapters. General applications and some special topics are considered in Chapter 7. To aid the reader, a list of symbols is included, and a list of references is given at the end of each chapter.

INTENSITY-RELATED DATA FOR SPECTRUM OF NEUTRAL IRON

A detailed knowledge of the spectrum of neutral iron (Fe I) is of great importance in laboratory spectroscopy, plasma physics, and astrophysics, as indicated by the large number of iron lines commonly found in stellar spectra. The solar spectrum, for example, has five times as many lines arising from iron as from any other element.

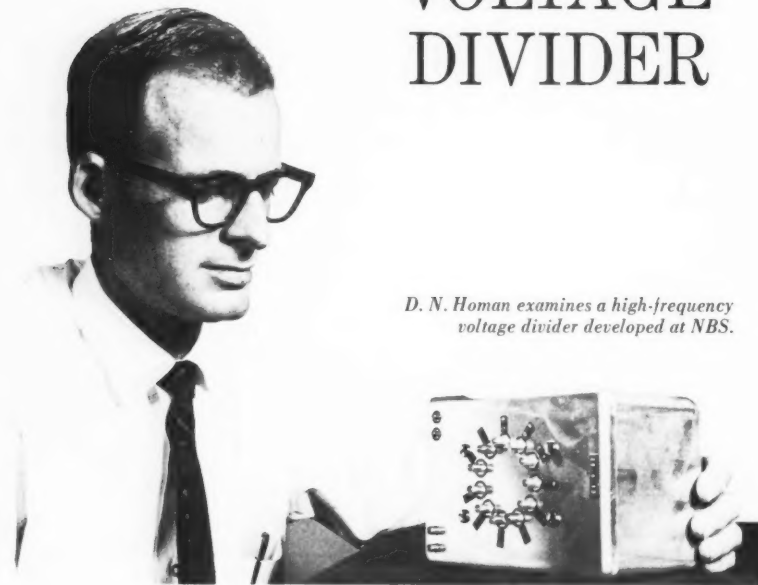
In view of the current interest in this spectrum, C. H. Corliss and J. L. Tech have compiled a homogeneous set of intensity-related data of g -values for 3288 lines of Fe I in the region from 2100 to 9900 angstroms. These values are distinguished from earlier presentations in that the new calculation of g -values removes an empirically determined excitation correction that had been applied to earlier measured values. The recalculation affects the values for all lines whose upper energy levels lie above 46 000 cm^{-1} and should significantly improve the internal consistency of the present data. These data are available in NBS Mono. 108, *Oscillator Strengths and Transition Probabilities for 3288 Lines of Fe I*² (66 pages, 45 cents).

STANDARD NUCLEAR INSTRUMENT MODULES

Practically all modular nuclear instrumentation currently produced in the United States is in accordance with the Nuclear Instrument Module (NIM) System. The AEC Committee on Nuclear Instrument Modules was formed in 1964 to draw up specifications for the standard modules to assure mechanical and electrical interchangeability. The standard issued by this committee was adopted and

continued on page 227

IMPROVED HIGH-FREQUENCY VOLTAGE DIVIDER



D. N. Homan examines a high-frequency voltage divider developed at NBS.

Voltage dividers are in considerable demand for electronic applications. When used with a definite, known input voltage they are a convenient means of providing definite, known lesser voltages. Such dividers are extensively used by electronic equipment manufacturers, by the military forces, and by electronics standards laboratories.

Although voltage dividers generally perform satisfactorily at audiofrequencies, accuracy has long been a problem at radiofrequencies. Recently, however, the NBS Institute for Basic Standards has achieved high accuracy in this range using a decade inductive voltage divider of special design developed by D. N. Homan and T. L. Zapf of the Institute's Radio Standards Engineering Division at Boulder, Colo. Thus far measurements with the divider have been limited to 100 kHz, but it is expected to be useful at much higher frequencies. The device should be of value as a standard for calibrating other di-

viders, as an instrument for measuring voltage ratio and attenuation, and as ratio arms in bridges used for impedance measurements.

This divider employs special guarding and two-stage transformer techniques¹ to reduce errors in voltage ratio at radiofrequencies. For example, measurements at 100 kHz with the new device indicate that the inherent errors in the in-phase component of voltage ratio are less than 5×10^{-7} of the input voltage. An analysis suggests that only a small fraction of these errors are inherent in the divider; the largest contribution to the errors appears to arise from sources related to the measurement process, including the input and output connections.

The NBS divider design overcomes the two major limitations on accuracy at high frequencies that are inherent in other available inductive voltage dividers; namely, (1) excitation current which causes voltage drops in the leakage inductances of the sections of

the winding, and (2) current from stray admittances between sections of the winding which causes voltage drops in the leakage inductances of the sections.

With the dividers that have been available, the net errors from sources such as these are quite small at low audiofrequencies, e.g., 5×10^{-7} at 1 kHz. To achieve this accuracy, magnetic cores having very high permeability are used to assure that the leakage inductances are extremely small as compared to the mutual inductances of the windings. In addition, special winding techniques are used to minimize errors. These techniques include the bundling of wires so as to randomize the wire position in the bundle. When such dividers are used at higher frequencies, however, errors in voltage ratio increase significantly, even though the design is scaled for optimization at higher frequencies.

In the present voltage divider the excitation current is reduced by using two-stage transformer techniques. The design includes two magnetic cores and two windings, a principal inductive divider winding and an excitation winding. The inductive divider winding is wound on both cores; one of the cores also has an excitation winding with the same number of turns as the inductor divider winding. The excitation winding on the one core induces most of the voltage in the inductive divider winding, and thus carries most of the excitation current. Consequently the inductive divider winding carries only that small fraction of excitation current necessary to provide the difference (as a self-induced emf) between the applied voltage and the voltage induced in the main winding by the excitation winding.

The stray admittances between the ten sections of the new divider are

NBS MEASUREMENT SEMINARS AND WORKSHOPS 1968-1969 Series

Seminars and workshops on 13 topics, listed below, have been announced for the 1968-1969 series of NBS Measurement Seminars and Workshops (previously called "Precision Measurement Seminars"). Except for the last two in the list, these are scheduled to be given either at the NBS laboratories in Gaithersburg, Md., indicated by (G), or in Boulder, Colo., indicated by (B). The announced topics are as follows:

- Problems in Metrication (G)
- Thermometry and Pyrometry (G)
- Low-Frequency Electrical Standards (G)
- Colorimetry and Spectrophotometry (G)
- Photometry (G)
- Length, Angle, and Geometry Measurements (G)
- Fundamentals for Gas-Laser Length Measurements (G)
- Frequency and Time Stability (B)
- Laser Power and Energy Measurements (B)
- High-Frequency and Microwave Power (B)
- High-Frequency Calibration Workshop (B)
- Precision and Accuracy¹
- High-Frequency and Microwave Impedance

The seminars and workshops are one of several NBS activities that provide advice and assistance on measurement and calibration problems to the growing number of standards laboratories in tracing to NBS standards the accuracies of measurement needed for research work, factory production, or field evaluation. Participation is open to a limited number of persons from measurement and standards laboratories who meet appropriate prerequisites relating to education, work experience, and current professional activity.

Each course (seminar or workshop) lasts from two to five days and its meetings are devoted to lectures, group discussions, and laboratory demonstrations. A course may be cancelled if registration is insufficient. However, in the past, requests for enrollment have nearly always exceeded the numbers that could be accommodated. Laboratory directors who wish to have members of their staff attend any of these courses are therefore urged to send, as soon as possible, a letter of application to the individual named in the course descriptions below. Letters should include details of the candidate's qualifications in terms of the stated prerequisites. The form at the end of this insert may be used for this purpose. Applications should also be accompanied by a check, billing authorization, or purchase order for the stated fee.

Acceptance of qualified applicants, on the basis of first come first served, other things being equal, will be made by letter not later than four weeks prior to the scheduled date of

the course. Detailed information on schedules and housing will be available at that time. Those accepted will be expected to study the assigned reading material before coming to the course and should be prepared to discuss their own experiences with related problems.

Problems in Metrication (G)

Brief Description: This 3-day seminar is designed to partly fulfill the needs of design and research and development engineers and of scientists who are encountering or expect to encounter problems arising from increasing use of the metric system. Subjects covered will include history, structure, development and use of the International System of Units, thinking in metric terms, U.S. standards and metric standards, development of dual capability, problems of screw threads, discussion of special problems proposed by attendees.

Prerequisites: Attendees must have a B.S. degree in engineering or one of the physical sciences or the equivalent in education and experience, and be engaged in design, research and development, measurement, planning, or managing activities that involve the subject matter of the seminar.

Arrangements: Participants will be selected on the basis of technical experience and professional responsibility. Fee: \$150. Dates: March 19, 20, 21, 1969. Apply to: A. G. McNish, National Bureau of Standards, Washington, D.C. 20234.

Thermometry and Pyrometry (G)

Brief Description: The 4-day seminar will deal with calibration of common types of thermocouples and thermocouple materials by the comparison method and the fixed point method; procedures for the calibration of refractory and noble metal thermocouples by direct comparison with an optical pyrometer; description and discussion of the thermodynamic Kelvin and International Practical Temperature Scales; the NBS acoustical thermometer and germanium resistance thermometers; platinum resistance thermometers from 13.8 to 1063 K; realization of IPTS and determination of brightness temperatures of nonblackbodies with an optical pyrometer; new problems and precautions with high-precision photoelectric pyrometers. Experimental apparatus and techniques used in primary and secondary calibrations will be discussed, and laboratory demonstrations will be included.

Prerequisites: Applicants must have college-level training in engineering or physics, or equivalent experience, and must be currently engaged at a professional level in standards

work involving precision temperature calibrations. Preparation should include a review of the NBS Special Publication 300, Vol. 2, *Temperature*, and NBS Monographs 37 and 41.

Arrangements: Group will be limited to 30, selected on the basis of academic qualifications and technical experience. Fee: \$175. Tentative dates: March 25, 26, 27, 28, 1969. Apply to: H. H. Plumb, NBS Heat Division, Washington, D.C. 20234.

Low-Frequency Electrical Standards (G)

Brief Description: Two 3-day seminars are planned to present information on the accurate measurement of electrical quantities and the calibration of electrical standards. Each will cover the measurement methods used by the Bureau to establish and maintain the basic electrical units and to calibrate customers' standards of resistance, inductance, capacitance, voltage, current, and power from direct current up through 30 kHz. The program of each seminar will consist of lectures and demonstrations in the Electricity Division laboratories. Emphasis will be on measurement techniques, which should be useful to workers in standards and calibration laboratories.

Prerequisites: Candidates must have college-level training in physics or electrical engineering and must be currently engaged in professional work in precise electrical measurements at a level involving the basic reference standards of a calibration or standards laboratory. Preference will be given to those whose position involves the training of others in precise electrical measurements.

Arrangements: Attendance at each seminar will be limited to 50 persons and, for laboratory demonstrations, each group will be divided into subgroups. Fee: \$115. Dates: April 14, 15, 16 and April 28, 29, 30, 1969. Apply to: R. F. Dziuba, NBS Electricity Division, Washington, D.C. 20234.

Colorimetry and Spectrophotometry (G)

Brief Description: A 3-day seminar that deals with color measurement in its psychological and physical aspects. Subjects to be treated are: The psychophysics of color vision, uniform color space, color-order systems, spectrophotometry, photodetector response, photoelectric colorimeters, automation of colorimetry, metamerism, variability of color measurement. The seminar will consist of lectures, discussions, and visits to NBS colorimetry and spectrophotometry laboratories.

Prerequisites: Candidates must have college-level training in physics, chemistry, engineering, or psychology, and be involved in experimental colorimetry or spectrophotometry, either in a direct or supervisory capacity. Prior to the seminar, candidates will be furnished with a list of references and copies of selected articles.

Arrangements: Group will be limited to 50, selected on the basis of academic qualifications and experience. Fee: \$150. Dates: May 5, 6, 7, 1969. Apply to: I. Nimeroff, NBS Metrology Division, Washington, D.C. 20234.

Photometry (G)

Brief Description: The 4-day seminar will cover: Fundamentals and nomenclature; photometry and the eye; characteristics of photodetectors; measurement of illuminance and luminance; measurement of luminous flux; photometric

standards; projection photometry; statistical control of photometric calibrations.

Prerequisites: Applicants must have college-level training in physics or engineering and must be currently engaged at a professional level in photometry or fields related thereto. Preparation for the seminar should include review of J. W. T. Walsh, *Photometry*.

Arrangements: Group will be limited to 50, selected on the basis of academic training and professional experience. Fee: \$200. Dates: May 12, 13, 14, 15, 1969. Apply to: C. A. Douglas, NBS Metrology Division, Washington, D.C. 20234.

Length, Angle, and Geometry Measurements (G)

Brief Description: The first two days of this 5-day seminar will be shared with the participants attending the Seminar on Fundamentals for Gas-Laser Length Measurements. Additional topics to be covered include: Absolute and mechanical gage block measurement, polygon and angle block measurement; interferometric measurement of optical flats and diameter; survey tape calibration; surface plate; surface texture and gear metrology. Experimental and statistical programs for determination of systematic, random, and instrumental error will be discussed. Theoretical development will be supplemented with laboratory sessions where class members can use NBS calibration equipment. Speaker at dinner will discuss U.S. problems in metrification. One open session will be provided for special individual appointment visits to other areas of interest.

Prerequisites: It is desirable that candidates have college-level training in engineering or physics or equivalent experience in precise dimensional metrology. Review of NBS Handbook 77, Vol. III, pp. 1-350; Ditchburn, *Light*, Ch. I-V, VII, IX, XIII, XIV, and Habbell and Cox, *Engineering Optics*, Ch. IV-VII will be helpful.

Arrangements: Group will be limited to 30, selected on basis of need for the training. Fee: \$280, which includes cost of one dinner and coffee breaks. Dates: May 12, 13, 14, 15, 16, 1969. Apply to: A. G. Strang, NBS Engineering Metrology Section, Washington, D.C. 20234.

Fundamentals for Gas-Laser Length Measurements (G)

Brief Description: Topics to be covered during the 2-day seminar are: Fundamental interferometry, length interferometry, light sources for interferometry, gas lasers, NBS laser instrumentation, practical pointers on use of lasers, laser alignment interferometers and holography.

Prerequisites: It is desirable that applicants have college-level training in engineering or physics or equivalent practical experience in precise dimensional metrology. Preparation should include review of Ditchburn, *Light*, Ch. I-IX, XIII-XV.

Arrangements: Group will be limited to 40. Fee: \$120. Dates: May 12, 13, 1969. Apply to: A. G. Strang, NBS Engineering Metrology Section, Washington, D.C. 20234.

Frequency and Time Stability (B)

Brief Description: The 4-day seminar will develop a language that will allow clear characterization of the instabilities in atomic frequency standards and in atomic clocks. Definitions of precision, accuracy, and stability will be

given allowing the supplier and the user to communicate on the specifications and capabilities of precise frequency standards and clocks. The seminar will show how to measure and what to expect in the short-, intermediate-, and long-term stability of cesium beams, hydrogen masers, rubidium gas cells, and quartz crystal oscillators. Seminar material will be pertinent in the following areas: Time dispersion in atomic clocks; use of portable clocks; time synchronization of timing centers; measurement and analysis of frequency and time data as may be used in calibrations, with information on low-noise techniques.

Prerequisites: Candidates must have college-level training in physics or electrical engineering, or equivalent experience, and must be working at a professional level with frequency standards or precise timing systems. Preparation for the seminar should include a review of pertinent parts of the February 1966 issue of the Proceedings of the IEEE. Other materials will be supplied at the time of acceptance notification and should be studied in preparation.

Arrangements: Attendance will be limited to 30. Tentative fee: \$150. Tentative dates: February 18, 19, 20, 21, 1969. Apply to: D. W. Allan, NBS Atomic Frequency and Time Standards Section, Boulder, Colo. 80302.

Laser Power and Energy Measurements (B)

Brief Description: The 2-day seminar will discuss the techniques used by NBS to calibrate various laser power and energy measuring devices. The wavelength range will be 488.0 nm to 10.6 μm ; cw power levels will range up to 200 W

and pulse energy to 100 J. Measurement of average power and peak power of high rep-rate lasers will also be discussed.

Prerequisites: Candidates must have college-level training in engineering or physics, or equivalent experience, and must be currently engaged in precision measurements at a professional level.

Arrangements: Attendance will be limited to approximately 40. Approximate fee: \$15. Tentative dates: March 3, 4, 1969. Apply to: Administrative Officer, NBS Radio Standards Physics Division, Boulder, Colo. 80302.

High Frequency and Microwave Power (B)

Brief Description: The 3-day program will include topics of interest to those concerned with rf power measurement and calibration in coaxial and rectangular waveguide systems. Areas to be covered include analysis and evaluation of calibration systems, mismatch and other transfer errors, and descriptions of NBS primary standards. Other topics such as measurement techniques and state-of-the-art instrumentation will be discussed. Accuracies and types of instruments used in Echelon I, II, and III laboratories will be given. Lectures and discussions will be supplemented by laboratory demonstrations.

Prerequisites: Candidates must have college-level training in engineering or physics, or equivalent experience, and must be currently engaged in precision measurements at a professional level.

Arrangements: Attendance will be limited to approximately 30. Tentative fee: \$200. Dates: March 26, 27, 28, 1969.

APPLICATION FOR REGISTRATION NBS MEASUREMENT SEMINARS AND WORKSHOPS

Title and date of course:

Date of application:

Applicant's name and address:

Company or agency affiliation:

Title of position in company or agency:

College level training:

Supervisory or laboratory experience related to measurement:

Available reprints of the material to be reviewed prior to the seminars and workshops will be mailed upon acceptance of this application.

Apply to: Paul A. Hudson, NBS Radio Standards Engineering Division, Boulder, Colo. 80302.

High-Frequency Calibration Workshop (B)

Brief Description: The 5-day workshop will cover quantities measured in presently available high-frequency calibration services from NBS. These will include cw power measurements; impedance and VSWR measurements; attenuation difference and insertion loss measurements; phase shift measurements; cw voltage measurements; antenna and field strength measurement techniques; effective noise temperature measurements; pulse voltage and power measurements. Oral presentations will include a discussion of the calibration techniques used at NBS, and the error analysis upon which NBS calibrations are based will be carefully explained. Extensive measurement theory will not be treated except as a necessary conceptual aid. Demonstrations of typical calibrations will be arranged and will compose a substantial portion of the program. Practical hints for solving some of the common high-frequency measurement problems will be included.

Prerequisites: The workshop is aimed at the "practicing metrologist." This is intended to include the more experienced operating technical calibration people and first-line supervisory calibration people. Some of the higher-level supervisory engineers in calibration laboratories also may find some benefit from the workshop.

Arrangements: Attendance probably will be limited to approximately 50. Approximate fee: \$300. Dates: April 21, 22, 23, 24, 25, 1969. Apply to: F. X. Ries, High-Frequency Calibration Services, NBS Radio Standards Engineering Division, Boulder, Colo. 80302.

High-Frequency and Microwave Impedance

Brief Description: This is a 3- to 5-day seminar. While the discussion will include background material on measurement philosophy, errors and accuracy, standards, the connector problem, and the effect of impedance on quantities such as power and attenuation, the major emphasis will be on techniques for making meaningful impedance measurements. The treatment will be nonmathematical and practical rather than theoretical.

Prerequisites: The seminar is aimed at "practicing metrologists"—the operating calibration technician and his first-line supervisor.

Arrangements: Approximate fee: \$300. The seminar will be presented on the East Coast and on the West Coast in January, February, or March of 1969. The exact dates and sites are still open. Apply to: L. E. Huntley, NBS Radio Standards Engineering Division, Boulder, Colo. 80302.

¹ A description of this seminar, scheduled for Oct. 7, 8, 9, 1968, at West Coast University, Orange, Calif., was given in the August 1968 issue of the NBS Technical News Bulletin.

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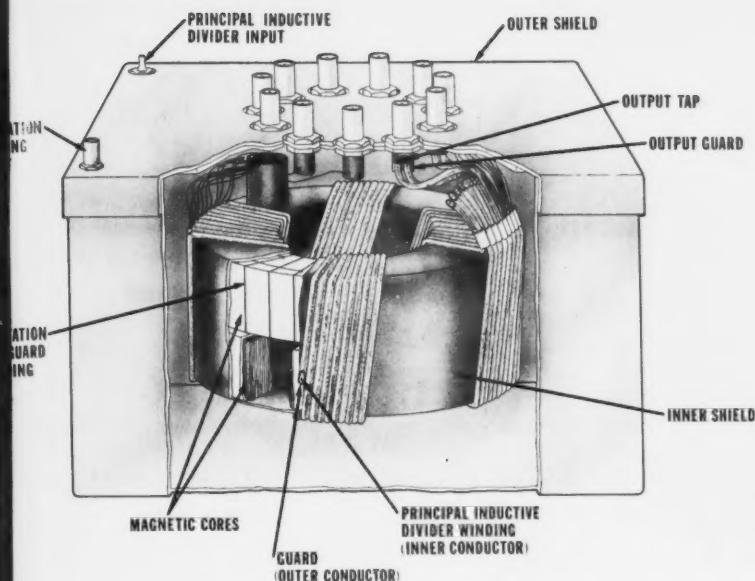
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Cutaway view of the voltage divider.

very nearly eliminated by a guard around the inductive divider winding. The inductive divider winding and the guard are coaxial and are made

from coaxial cable. The cable's inner conductor is the inductive divider winding; its outer conductor is the guard. The guard is broken at the

end of each section and guard potential is applied to the center of each guard section. The guard potentials are generated at taps brought out from the excitation winding on the single core.

Performance characteristics of the new divider (which may be called a two-stage, guarded, decade inductive voltage divider) and the limitations of the design are now being investigated. Errors in voltage ratio are being measured by a step-up method² using equipment designed for 100 kHz operation. Further work will be directed toward examination of errors introduced by the input and output connections. Also, performance over a wide frequency span will be examined.

¹ Cutkosky, R. D., Active and passive direct reading ratio sets for the comparison of audio-frequency admittance, J. Res. NBS 68C (Engr. and Instr.), No. 4, 227 (Oct.-Dec. 1964).

² Sze, W. C., An injection method for self-calibration of inductive voltage dividers, J. Res. NBS 72C (Engr. and Instr.), No. 1, 49 (Jan.-Mar. 1968).

CONFERENCE BRIEFS *continued*

implemented with astonishing rapidity by laboratories and industries throughout the world. Thus, it has dramatically alleviated the interchangeability problem that accompanied the advent of transistorized modular instruments.

A second revision of the module specifications has now been issued to permit dispensing with all previous addenda and supplements. Prepared by Louis Costrell of the NBS Center for Radiation Research, *Standard Nuclear Instrument Modules*,² TID-20893 (Rev. 2), January 1968 (32 pages, 25 cents) lists specification requirements, together with comments and drawings. Information on various items, such as logic levels and connector pin assignments, which formerly appeared only in the drawings, has been included in the report.

SCHEDULED NBS-SPONSORED CONFERENCES

Each year NBS sponsors a number of conferences covering a broad range of topics in science and technology. The conferences listed below are either sponsored or co-

sponsored by NBS and are open to all interested persons unless specifically noted. If no address is indicated, the conference will be held at NBS, Gaithersburg, Md., and inquiries should be sent in care of Special Activities Section, Rm. A600, Administration Bldg., National Bureau of Standards, Washington, D.C. 20234.

Standards for High Pressure Research. Oct. 14-18. Contact: C. W. Beckett (NBS Heat Division).

American Cybernetics Association. Oct. 23-25. Contact: Carl Hammer (UNIVAC).

Seminar on Durability of Insulating Glass. Nov. 14-15. Cosponsor: ASTM Committee E-6 on Methods of Testing and Building Construction. Contact: Henry Robinson (NBS Building Research Division).

Workshop on Mass Spectrometry. Nov. 18-19. Contact: A. J. Ahearn (NBS Analytical Chemistry Division).

Symposium on Natural Products. Dec. 12. Cosponsor: Chemical Society of Washington. Contact: G. Brauer (NBS Polymers Division).

¹ Manning, John R., *Diffusion Kinetics for Atoms in Crystals*, D. Van Nostrand Co., Inc., Princeton, N.J., 1968, 245 pages. Price, \$9.75.

² Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.



NEWS

This column regularly reports significant developments in the program of the National Standard Reference Data System. The NSRDS was established in 1963 by the President's Office of Science and Technology to make critically evaluated data in the physical sciences available to science and technology on a national basis. The System is administered and coordinated by the National Bureau of Standards through the NBS Office of Standard Reference Data, located in the Administration Building at the NBS Gaithersburg Laboratories.

Standard Reference Data Act Passed

On July 11, 1968, the Standard Reference Data Act became law. Section 1 of the Act declares:

"The Congress hereby finds and declares that reliable standardized scientific and technical reference data are of vital importance to the progress of the Nation's science and technology. It is therefore the policy of the Congress to make critically evaluated reference data readily available to scientists, engineers, and the general public. It is the purpose of this Act to strengthen and enhance this policy."

The Act authorizes and directs the Secretary of Commerce to set up a comprehensive standard reference data system within the Department, and provides certain additional authorities needed for the efficient operation of the program.

In hearings on the Bill that preceded the enactment, Congressman E. Daddario declared that a strengthened standard reference data system was essential for the efficient conduct of the Nation's research and development effort. The purpose of the National Standard Reference Data System (NSRDS) is to deal with an important aspect of the broad science information problem by producing and disseminating compilations of critically evaluated quantitative data on the physical and chemical properties of materials. It makes data of known reliability conveniently available to scientists and engineers, thereby relieving them of the time-consuming necessity of searching the available literature and attempting to evaluate data in fields in which they may not be expert. NSRDS provides a systematic approach to the work that has been done in a piecemeal, uncoordinated, and less efficient manner by

individual members of the scientific and technical community. Congressman Daddario has observed that the present lack of a comprehensive standard reference data system has cost the Nation hundreds of millions of dollars a year in duplicated work, wasted effort, equipment failures, and equipment that has been over-designed to compensate for lack of critically evaluated data.

To accomplish the purposes of the National Standard Reference Data Act, the Secretary of Commerce has received increased authority, which includes discretionary authority to copyright materials from the program. This will permit a sales price and policy that would return some funds to NSRDS, thereby lowering the support cost of the program to the public.

In summary, Public Law 90-396 provides the legal framework necessary for a more comprehensive expanded standard reference data system.

Partial Grotrian Diagrams

About 40 years ago, German scientist W. Grotrian devised a graphical representation for the relationship of characteristic spectrum lines of various atoms and ions to their quantum energy levels, and gave many examples for atoms and ions with one, two, and three valence electrons. These "Grotrian diagrams" have been of great value to astronomers as well as to physicists.

NSRDS-NBS-23, *Partial Grotrian Diagrams of Astrophysical Interest*¹ (55 cents), by Charlotte E. Moore and Paul W. Merrill, is an exact reprint of Appendix A of the book by the late Paul W. Merrill entitled *Lines of the Chemical Elements in Astronomical Spectra*. This book was published in 1956 as a Carnegie Institution of Washington Publication (Number 610).

NSRDS-NBS-23 contains partial Grotrian diagrams of selected spectra of astrophysical interest that give wavelengths, multiplet numbers, and key letters for the transitions shown. The diagrams are accompanied by tabular keys in which the key letters indicate related lines in spectra similar in structure to those illustrated in the diagrams. There are 39 diagrams of spectra between hydrogen and nickel and tabular keys for 90 spectra between lithium and rhenium.

When Mr. Merrill was planning his publication, he re-

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quested Dr. Moore to prepare a set of selected partial Grotrian diagrams for inclusion as Appendix A. Since the 1956 publication of his book, many scientific researchers have found valuable use for the Grotrian diagrams. Continued requests for copies of the Grotrian diagrams have indicated a need for making them more generally available. The Carnegie Institution of Washington generously gave permission to the Office of Standard Reference Data to reprint the Grotrian diagrams as a separate publication.

Rigid Asymmetric Rotor Tables

NSRDS-NBS-12, *Tables for the Rigid Asymmetric Rotor: Transformation Coefficients from Symmetric to Asymmetric Bases and Expectation Values of P_x^2 , P_y^2 , and P_z^2* (60 cents), by R. H. Schwendeman, has been published. The rigid asymmetric rotor provides the first approximation for treating the rotational energy of asymmetric molecules. It is thus of considerable importance in the interpretation of both pure-rotational spectra and the rotational fine structure in vibrational and electronic bands. The quantum mechanics of the rigid asymmetric rotor has been discussed in many places, and several tabulations of energy eigenvalues and direction-cosine matrix elements are available. For some purposes, however, it is necessary to have an explicit description of the asymmetric rotor eigenfunctions. This can be given most conveniently in terms of the transformation coefficients from a symmetric rotor basis to the asymmetric rotor basis.

NSRDS-NBS-12 presents tables of computed quantities associated with the rigid asymmetric rotor. The first part of this volume is a tabulation of transformation coefficients for varying degrees of asymmetry. The first group of tables gives transformation coefficients from symmetric to asymmetric rotor bases. These coefficients permit the eigenfunctions of the asymmetric rotor to be written in terms of symmetric-rotor eigenfunctions. In the second part, the angular-momentum expectation values P_x^2 , P_y^2 , and P_z^2 are tabulated. In both sets of tables values are given at intervals of 0.1 in the asymmetry parameter k and for $J \leq 15$. The tabulated quantities find use in the analysis of microwave rotational spectra and the rotational fine structure in vibrational and electronic band spectra.

Microwave Spectral Tables

NBS Monograph 70, Volume V, *Microwave Spectral Tables, Spectral Line Listing*¹ (\$4.75), by Marian S. Cord, Matthew S. Lojko, and Jean D. Petersen, is the last of a planned five-volume series. The series presents a comprehensive compilation of microwave spectra, including measured frequencies, assigned molecular species, assigned quantum numbers, and molecular constants determined from these data. Volume I, *Diatom Molecules*, Volume II, *Line Strengths of Asymmetric Rotors*, and

Volume V, *Spectral Line Listing*, have been published. Volume III, *Polyatomic Molecules with Internal Rotation*, and Volume IV, *Polyatomic Molecules Without Internal Rotation*, are both in press.

Volume V, *Spectral Line Listing*, will be of interest to microwave spectroscopists and those who apply microwave spectroscopy to analytical and other practical purposes. The great accuracy with which microwave lines can be measured, the broad range of frequencies that can be covered, and the sharpness of microwave lines make this field of spectroscopy comparable to optical atomic spectroscopy in many ways.

This volume is a listing of the spectral lines reported in Volumes I, III, and IV. The lines have been automatically sorted and are listed according to ascending frequency. For each spectral line, data are given in the following order: The formula for the molecular isotopic species; the number of the volume of the series in which the line was originally tabulated; the identification number used in that volume for ready reference; the rotational quantum number; the frequency and its accuracy.

In a foreword written for Volume V, E. Bright Wilson, Harvard University, comments: "Naturally, no set of tables of this kind can be complete, either with respect to the substances covered or the spectral lines of any given substance, so the fact that an observed line is not listed in these tables is not usually meaningful. However, if the spectrum of a given substance has been partly mapped and listed herein, its presence in a mixture (if its proportion is high enough) should be readily detected if enough of the observed lines are searched for in the present listing. When a line has been tentatively identified, one can then turn to Volumes I, III, or IV of this series and look for other known strong lines of the substance to use as corroboration."

Thermodynamic Properties of Ammonia

Critically evaluated data on the thermodynamic functions for ammonia as an ideal gas at atmospheric pressure have been published as NSRDS-NBS-19¹ (20 cents), *Thermodynamic Properties of Ammonia as an Ideal Gas*. In this publication by Lester Haar, the ideal gas thermodynamic properties of ammonia in the ground electronic state are calculated and presented in tables at closely spaced temperature intervals from 50 to 5000 K. The calculations include the contributions of ordinary vibrational anharmonicity and vibrational-rotational coupling together with rotational stretching and rotational quantum effects. Mr. Haar gives particular attention to the treatment of rotational and vibrational anharmonic effects caused by molecular inversion. The thermodynamic functions presented in the tables include C_p°/R , $(H^\circ - E_0^\circ)/RT$, $(E_0^\circ - G^\circ)/RT$, and S°/R .

¹ These publications are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.



STANDARDS AND CALIBRATION

STANDARD PLATINUM RESISTANCE THERMOMETERS

The calibration facilities for standard platinum resistance thermometers at the National Bureau of Standards are again fully operational. At the same time, because of changes in equipment and procedure instituted during the suspension of services, the accuracy of some of the services has been improved and the turn-around time for all of them has been shortened materially.

Services were interrupted in the first place because of the move of NBS from its former location in Washington, D.C., to new laboratories in Gaithersburg, Maryland. However, the dismantling of the calibration apparatus, which the process of removal made necessary, gave an excellent opportunity for introducing a number of improvements that were then under development, and this occasioned further delays. Some of the services were resumed over a year ago; others, in particular the calibrations in the low-temperature range between 10 K and 90 K, where changes in apparatus were most extensive, could not be made available again until quite recently.

In the temperature range from about 300 °C to 630 °C (about 573 K to 903 K), calibration errors have been reduced by roughly a factor of two, primarily as a result of substituting the freezing point of zinc for the boiling point of sulfur as a reference temperature. Test results in the 10 K to 90 K range, which are still being analyzed, also show a distinct improvement in accuracy.

Turn-around time has also been substantially improved. For any one specified calibration, the time interval from the date of receipt (of both the Purchase Order and the thermometer) to the date on which the material is shipped back to the customer, is expected not to exceed six weeks. Previously, in contrast, the interval was rarely less than three months.

The services involved are those listed under item numbers 221.113a through 221.113h, as described in the publication, *Calibration and Test Services of the National Bureau of Standards*.¹

COAXIAL BOLOMETER UNITS WITH 7-mm CONNECTORS

Over the Frequency Range of 4 to 17 GHz

A calibration service for the measurement of effective efficiency² of coaxial bolometer units fitted with 7-mm precision-type connectors has been announced by the Radio Standards Engineering Division (Boulder, Colo.) of the NBS Institute for Basic Standards. The recent availability of 7-mm precision-type connectors³ has made it possible to extend the frequency range to 17 GHz. The

former calibration range of coaxial bolometer units was limited to 10 GHz.

Coaxial bolometer units calibrated by NBS are used as interlaboratory standards and form the principal link to the NBS reference standards of radiofrequency power in coaxial equipment. The calibrated bolometer units can be used by other standards laboratories to calibrate their power measurement devices. They also serve as an accurate means of checking the operation of power measuring systems.

The calibration of coaxial bolometer units in the frequency range of 4 to 17 GHz is based upon two methods of calibrating waveguide bolometer units, used as working standards, in terms of waveguide reference standards. In the range of 3.95 to 7.05 GHz use is made of the impedance method of measuring the efficiency of the working standards. In the range from 7.05 to 17 GHz the calorimetric method is used. In turn, the waveguide working standards are used to calibrate coaxial bolometer units by the adapter method,⁴ the final result being an accurate measurement of effective efficiency over a wide frequency range that is obtained by this two-step procedure. Although a transfer is made from one type of transmission line to another in the second step, the uncertainty in measurement of effective efficiency of a coaxial unit is reasonably small.

Calibrations can be performed at any rf power level between 1 and 10 milliwatts. Limits of uncertainty of measurement are dependent upon the frequent of calibration and upon impedance characteristics of the bolometer unit. For a reflection coefficient magnitude no greater than 0.25, the uncertainty is lowest (± 0.8 percent) in the range of 7.05 to 12.4 GHz. Similarly, the limits of uncertainty are ± 1.3 percent in the frequency range of 4 to 7.05 GHz and ± 1.2 percent in the range of 12.4 to 17 GHz.

STANDARD FREQUENCY AND TIME BROADCASTS

WWV—2.5, 5.0, 10.0, 15.0, 20.0, and 25.0 MHz

WWVH—2.5, 5.0, 10.0, and 15.0 MHz

WWVB—60 kHz

Radio stations WWV (Fort Collins, Colo.) and WWVH (Maui, Hawaii) broadcast signals that are kept in close agreement with the UT2 scale by making step adjustments of 100 ms as necessary. Each pulse indicates that the earth has rotated approximately 15 arcseconds about its axis since the previous one. The pulses occur at intervals that are longer than one second by 300 parts in 10^{10} due to an offset in carrier frequency coordinated by the Bureau International de l'Heure (BIH), Paris, France.

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Adjustments are made at 0000 UT on the first day of a month. There will be no adjustment made on November 1, 1968.

Radio station WWVB (Fort Collins, Colo.) broadcasts seconds pulses derived from the NBS Time Standard (NBS-III) with no offset. Step adjustments of 200 ms are made at 0000 UT on the first day of a month when necessary. BIH announces when such adjustments should be made in the scale to maintain the seconds pulses within about 100 ms of UT2. There will be an adjustment made on

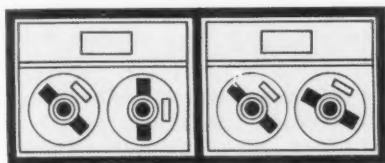
November 1, 1968. The seconds pulses emitted from WWVB will be retarded 200 ms.

¹ Calibration and Test Services of the National Bureau of Standards, NBS Spec. Publ. 250, 1968 ed., for sale at \$1.75 per copy by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

² The effective efficiency of a bolometer unit is the ratio of substituted dc power in the bolometer unit to the rf power dissipated within the unit.

³ IEEE Standard No. 287 for Precision Coaxial Connectors. To be published in the September 1968 issue of IEEE Trans. Instr. Meas.

⁴ Engen, G. F., Coaxial power meter calibration using a waveguide standard, J. Res. NBS 70C (Engr. and Instr.), No. 2, 127-138 (Apr.-June 1966).



Information Processing

STANDARDS FOR REMOTE COMPUTER OPERATION

Early Voluntary Standardization Sought

The present and anticipated rapid growth in the number of persons having access to computers from remote terminals has led the NBS Center for Computer Sciences and Technology to appraise the need for standardizing user procedures and data formats. John L. Little of the Center has directed this work, which includes a study by Rockford Research Institute, Inc. Mr. Little and Calvin N. Mooers of Rockford conclude¹ that the users' dialogue with the computer system can take place with the use of a small number of stylized terms, facilitating standardization.

Today a scientist or businessman subscribing to a commercial service gets access to the central computer from his own "terminal," a typewriterlike keyboard and circuitry for connecting the two by a telephone line. Now more than 2000 units have access to shared computers and it is expected that by 1972 something like 300 000 terminals will be incorporated in about 15 000 storage and processing complexes, large and small.

To obtain computer services the subscriber has only to place a telephone call and then keyboard his identification, data, and instructions. The computer output he wants can be printed out, in most cases virtually immediately, by the same terminal.

Unfortunately there is almost no agreement among the various systems on means of calling for the same operation. If present trends are not successfully opposed, users may find themselves increasingly confused about how to "speak" with the computer—much like a traveler unsure of whether to ask directions in French, Spanish, or Portuguese.

With disappearance of the original novelty of the computer, its users are becoming less inclined to endure technical difficulties, such as having to learn more than one system language. This is of economic importance to computer systems, which to survive must sell their services.

Computer systems now benefit from standardization in certain areas. On the media level, for example, magnetic tape is found to be of specified widths, thicknesses, and magnetic characteristics. Hollerith cards are of a certain size and have punches of the size and locations that are readily machine recognizable.

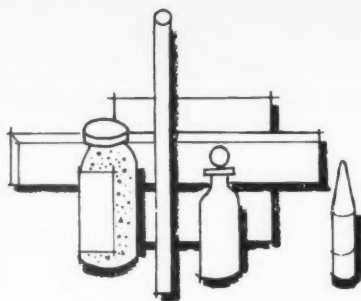
Another area of successful standardization is data encoding; all users of punched cards recognize that punches in a certain two positions of a column represent an "A." Underway at present are efforts to standardize computer language; USASCII (The USA Standard Code for Information Interchange) may ultimately serve all Federal and other computer users.

Now needed by the computer user community is standardization of procedures for communicating with the central computer. User signals to gain access to the system, to delete, and to stop an operation, for example, should be as universally recognized as is the meaning of an octagonal red sign at an intersection.

Unfortunately, not enough similarity in usage exists among computer services to select a form that is a consensus; codes suggested by any standardizing committee will no doubt be unfamiliar to most users. However, standards should be selected and advanced now to avoid greater cost later.

¹ Little, J. L., and Mooers, C. N., Standards for user procedures and data formats in automated information systems and networks, Proc. Spring Joint Computer Conference, Atlantic City, N.J., Apr. 30-May 2, 1968 (Thompson Book Co., Washington, D.C.).

STANDARD REFERENCE MATERIALS



Standard Reference Materials are well-characterized materials disseminated by NBS to be used in calibrating and evaluating measuring instruments, methods, and systems or to produce scientific data that can be referred readily to a common base. These materials are certified for chemical composition or for a particular physical or chemical property. They are used on-site in science and industry for calibrating the instruments and methods used for production and quality control of raw materials, chemicals, metals, ceramics, fuels, and radioactive nuclides in manufacturing processes and in research. This column regularly reports on the issuance of new and renewal Standard Reference Materials and on latest developments in the Standard Reference Materials Program.

pD AND pH STANDARDS ISSUED

Eight new standards have recently been added to the more than 650 standards available from the NBS Office of Standard Reference Materials.¹ These standards are for use in preparing five standard buffer solutions that define specific values of ion activity on the pD and pH scales.

Of the eight standards, five are used to make three buffer solutions defining ion activity values on the pD scale, while the others make two buffer solutions for use with the pH scale.

pD Standards

Since World War II, the use of heavy water (D_2O , deuterium oxide) has increased greatly, particularly in nuclear technology, chemical synthesis, and biomedical research. For example, nuclear magnetic resonance has become a convenient tool for following chemical reactions in solution. The solvent must be deuterium oxide rather than water because the hydrogen ions (or protons) in water would obliterate the resonance of the protons of the compound being studied.

Such use of heavy water required the development of a pD scale to measure the pD values of deuterium-containing solvents. NBS scientists did this,² and have now developed standards with which commercial glass electrode pH meters may be used to give experimental pD values with an uncertainty of less than 0.02 pD unit.³

The new pD standards are: NBS No. 2186-I, Potassium Dihydrogen Phosphate; NBS No. 2186-II, Disodium Hydrogen Phosphate; NBS No. 2190, Potassium Dihydro-

gen Citrate; NBS No. 2191, Sodium Bicarbonate; and NBS No. 2192, Sodium Carbonate. The $pD(S)^*$ values of buffer solutions made with these materials in heavy water are certified over a temperature range from 5 to 50 °C. NBS Nos. 2186-I and 2186-II are used to form a single standard buffer solution, as are Nos. 2191 and 2192; NBS No. 2190 makes a third standard buffer solution.

The potassium dihydrogen phosphate (KH_2PO_4), disodium hydrogen phosphate (Na_2HPO_4), sodium bicarbonate ($NaHCO_3$), and sodium carbonate (Na_2CO_3) used in these standards are from lots prepared to ensure high purity and uniformity. They meet the specifications of the American Chemical Society for reagent-grade chemicals, but should not be considered entirely free from impurities, such as traces of water, free acid or alkali, carbon dioxide, chlorides, sulfur compounds, and heavy metals.

The $pD(S)$ values were derived from the emf of cells without liquid junctions by a method of calculation analogous to that for the assignment of $pH(S)^*$ values.⁴ The uncertainty of the assigned values for $pD(S)$ is estimated not to exceed 0.01 unit.

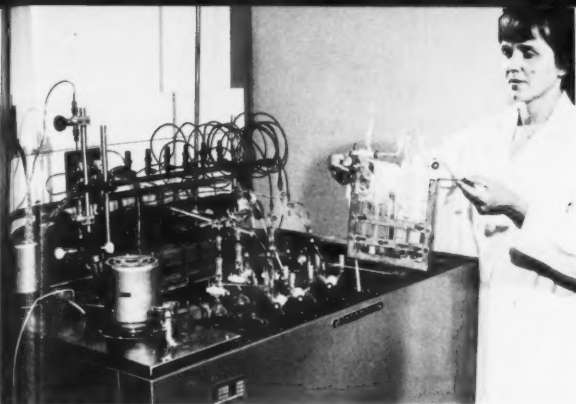
The research leading to the development of these standard reference buffers was performed by Maya Paabo and Roger G. Bates of the NBS Analytical Chemistry Division.⁵ NBS Nos. 2186-I, 2186-II, 2191, and 2192 cost \$36 for 30-gram units; and NBS No. 2190 costs \$40 for 60-gram units. All are sold with certificates of analysis and directions for use.⁵

pH Standards

The new pH standards are: NBS No. 190, Potassium Dihydrogen Citrate; No. 191, Sodium Bicarbonate; and No. 192, Sodium Carbonate. The $pH(S)^*$ values of the standard buffer solutions prepared with these standards in water are certified over a temperature range from 0 to 50 °C. NBS Nos. 191 and 192 are combined to form a single standard buffer solution while No. 190 makes another standard buffer solution.

In a 0.05M solution, No. 190 has a $pH(S)$ of 3.78. Thus, its pH lies between that of the saturated potassium acid tartrate solution (made from NBS Standard No. 188)

^{*}The terms $pD(S)$ and $pH(S)$ refer to ion activities of standard buffer solutions (S).



Standards for *pD* measurements in heavy water have been established with cells such as the one being placed into the thermostat by Maya Paabo.

and the 0.05*m* solution of potassium acid phthalate (made from NBS Standard No. 185d). However, the citrate buffer is much more stable than the tartrate buffer and is not subject to reduction at the hydrogen electrode, as is potassium hydrogen phthalate. The buffer solution consisting of 0.025*m* sodium bicarbonate (No. 191) and 0.025*m* sodium carbonate (No. 192) has a *pH*(S) of 10.00, which extends the scale 0.8 unit in the basic direction.

The values were derived from the emf of cells without liquid junction.⁴ The uncertainty of the assigned *pH*(S)

value is estimated not to exceed ± 0.005 *pH* unit from 0 to 50 °C.

The lots of sodium bicarbonate (NaHCO_3) and sodium carbonate (Na_2CO_3) were prepared to ensure high purity and uniformity. They meet the specifications of the American Chemical Society for reagent-grade materials but should not be considered entirely free from impurities, such as traces of water, free acid or alkali, silica, chlorides, sulfur compounds, and heavy metals.

The research leading to the preparation and certification of these new standard reference buffers was performed by Bert R. Staples and Roger G. Bates of the NBS Analytical Chemistry Division.³

NBS Nos. 191 and 192 cost \$28 for 30-gram units, and NBS No. 190 costs \$40 for 60-gram units. They are sold with certificates of analysis and directions for use.⁵

¹ For a complete list of Standard Reference Materials available from NBS, see *Standard Reference Materials: Catalog and Price List of Standard Materials Issued by the National Bureau of Standards*, NBS Misc. Publ. 260 (1968 ed.), for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 45 cents. Quarterly insert sheets which update Misc. Publ. 260 are supplied to users on request.

² Gary, R., Bates, R. G., and Robinson, R. A., Second dissociation constant of deuterophosphoric acid in deuterium chloride from 5 to 50°—Standardization of a *pD* scale, *J. Phys. Chem.* 68, 3806 (1964).

³ Bates, R. G., Standardization of acidity measurements, *Anal. Chem.* 40, 28A (May 1968).

⁴ Bates, R. G., Revised standard values for *pH* measurements from 0 to 95 °C, *J. Res. NBS* 66A (Phys. and Chem.), 179 (1962).

⁵ These standards may be purchased for the price indicated from the Office of Standard Reference Materials, Rm. B308, Chemistry Bldg., National Bureau of Standards, Washington, D.C. 20234.

PATENTS GRANTED ON NBS INVENTIONS

The following patents have been granted to NBS inventors and are assigned (or licensed as indicated) to the United States of America, as represented by the Secretary of the Department noted in parentheses:

3,329,957 July 4, 1967

Antenna System Employing Human Body as Radiator. (Commerce) Dagfin S. Hoynes

3,331,228 July 18, 1967

Combination Lock. (GSA) Richard W. Armstrong

3,331,656 July 18, 1967

Chemically Crimping Nylon Fibers Through Formation of Disulfide Bonds Therein. (Commerce) Stephen D. Bruck

3,339,948 Sept. 5, 1967

Pipe Coupling. (Air Force) Daniel H. Weitzel

3,354,411 Nov. 21, 1967

Coaxial Transmission Line T-Junction Having Rectangular Passageway Dimensioned Beyond Cutoff for Higher Order Modes. (Commerce) Myron C. Selby

3,354,544 Nov. 28, 1967

Method and Apparatus for Making Electrical Elements. (Navy) Frank E. Jones and Alfred B. Castle, Sr.

3,366,562 Jan. 30, 1968

Method of Conducting Electrolysis in a Solid Ionic Conductor Using an Electron Beam. (Commerce) Abner Brenner

3,371,036 Feb. 27, 1968

Method and Apparatus for Growing Single Crystals of Slightly Soluble Substances. (Commerce) John L. Torgeson and H. Steffen Peiser

3,371,064 Feb. 27, 1968

Fluorophenyl Vinyl Ethers and Their Polymers. (Navy) Leo A. Wall and Walter J. Plummer

3,375,387 Mar. 26, 1968

Fluid Cooled Multi-Foil Beam Window for High Power Beam Tubes. (Commerce) James E. Leiss, Samuel Penner, and John L. Pararas

3,378,257 Apr. 16, 1968

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- Material. (Commerce) Ira D. Boynton and Robert H. Bode
3,378,351 Apr. 16, 1968
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[Note: In the July 1968 Technical News Bulletin, the following patents were either omitted or listed incorrectly.]

- 3,230,366 Jan. 18, 1966
Universal Stroboscopic Electron Schlieren Detector Having Beam-Pulse Synchronizing Means. (Navy)
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3,276,062 Oct. 4, 1966
Mercury-Adsorbent Retrieving Devices. (Commerce)
Francis J. Palumbo
3,281,679 Oct. 25, 1966
Modulated Subcarrier System for Measuring Attenuation and Phase Shift. (Commerce) George E. Shafer

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- Technical News Bulletin*, Volume 52, No. 9, September 1968. 15 cents. Annual subscription: Domestic, \$3; foreign, \$4. Available on a 1-, 2-, or 3-year subscription basis.
Journal of Research of the National Bureau of Standards.
Section A. *Physics and Chemistry*. Issued six times a year. Annual subscription: Domestic, \$6; foreign \$7.25. Single copy, \$1.
Section B. *Mathematical Sciences*. Issued quarterly. Annual subscription: Domestic, \$2.25; foreign, \$2.75. Single copy, 75 cents.
Section C. *Engineering and Instrumentation*. Issued quarterly. Annual subscription: Domestic, \$2.75; foreign, \$3.50. Single copy, 75 cents.

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- Bates, R. G., Ed., *Electrochemical Analysis Section: Summary of activities, July 1967 to June 1968*, Tech. Note 453 (July 1968), 55 cents.
Beam, A. E., and Hilsenrath, J., *PRECISE: A multiple precision version of Omnitab*, Tech. Note 446 (June 1968), 55 cents.
Editorial format for Product Standards, PSO-67 (July 1968), 10 cents.
Hall, L. A., *A bibliography of thermophysical properties of methane from 0 to 300° K*, Tech. Note 367 (May 1968), 60 cents.
Moore, C. E., and Merrill, P. W., *Partial Grotrian diagrams of astrophysical interest*, NSRDS-NBS-23 (June 1968), 55 cents.
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